

## DOCUMENT RESUME

ED 276 885

CE 046 007

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TITLE Computer Aided Design in the Classroom.  
PUB DATE Dec 86  
NOTE 30p.; Paper presented at the Annual Convention of the American Vocational Association (Dallas, TX, December 6, 1986).  
PUB TYPE Information Analyses (070) -- Speeches/Conference Papers (150)  
EDRS PRICE MF01/PC02 Plus Postage.  
DESCRIPTORS Computer Software; \*Courseware; \*Drafting; Fused Curriculum; Integrated Curriculum; \*Media Selection; Postsecondary Education; \*Program Development; Secondary Education; Teaching Methods; \*Trade and Industrial Education  
IDENTIFIERS \*Computer Assisted Design

## ABSTRACT

Estimates calling for 1.2 million computer-assisted design (CAD) operator positions to be available by 1990 have prompted educational institutions throughout the country to incorporate instruction in CAD into their industrial arts curricula. Therefore, the question for schools is not whether to buy but rather what to buy. An effective strategy for purchasing CAD software should include the following steps: formation of a selection committee, comprehensive research on the concepts of CAD, formulation of a rationale for purchase, consideration of at least 15 points before selecting a CAD system, and negotiation with several vendors once a CAD system has been chosen. There are three approaches to establishing CAD competencies in any drafting setting. Instruction in CAD can be introduced (1) after students have developed proficiency in manual skills and a drafting discipline, (2) by establishing competency in a drafting discipline using computers instead of drawing boards, or (3) by first establishing an elementary competency in a drafting discipline using freehand sketching and then using CAD and manual skills together for industrial-quality work. Regardless of the integration method chosen, students working with CAD software need to develop prerequisite competencies in basic programming, trigonometry and analytical geometry, and a drafting discipline. (Appendixes to this report include lists of publishers of recommended course materials and microcomputer CAD software vendors, a form for evaluating CAD systems, and a directory of microcomputer CAD systems for education.) (MN)

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# Computer Aided Design in the Classroom

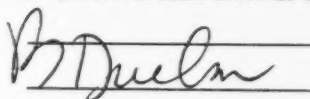
A paper presented at the  
American Vocational Association Annual Conference  
December 5-9, 1986  
Dallas, Texas

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## INTRODUCTION

There is no question that computer-aided design has found its place in the backbone of American industry. As the interface between man and machine, CAD serves to integrate the maximum capabilities of each to rise above the manual drafter in applying the concepts of engineering graphics. Industry realizes the benefits of CAD; this can be seen in a 1985 study by Arthur Neilsen of Vincennes University. His study found that sixty percent of local industrial CAD users are devoted to CAD 100%. His study also unveiled that sixty-five percent of interviewees stated that students should learn one type of system. Groves, in his article "Selecting a CAD System" stated "Rest assured, the revolution taking place in drafting is real. In fact, business and industry are converting to CAD faster than once projected. The growing demand for CAD operators reflects this conversion--with an estimate that over 1.2 million new jobs will be created by 1990. In response, educational institutions must quickly incorporate CAD instruction into various vocational/technical and engineering areas (Groves, 1984)."

Much of the initial educational response came from the university level. In 1978 a conference of the Deans of the Colleges of Engineering at the Big Ten Universities indicated "The urgent need for development of computer graphics as a key element in engineering curricula." (Thorsen, Lee, Wei, 1985). Since that time the University of Illinois has integrated the IBM PC based AutoCAD into the engineering curricula. Purdue University starts their students on the Apple microcomputer based MATCCAD before turning them loose on the 1.3 million dollar Computervision main-frame system. Colorado State University has implemented a CAD course using AutoCAD (Wohlers, 1984). At Indiana State University, the Industrial Technology Education department uses Apple IIE based MATCCAD and CADApple software for experimentation by students;

the Manufacturing and Construction, and Industrial Mechanical departments are preparing to release AutoCAD for use by the student population to expand upon the 4 minicomputer based Medusa CAD workstations. However, educators must realize that many apprentice drafters are not college graduates. They are products of the secondary industrial vocational and technical system. Who will address these students?

In October 1985, Purdue University held a "CAD awareness conference" to orient Indiana technical teachers to the oncoming technology. The response was overwhelming as more than 100 technology teachers attended. Many of these teachers had not been introduced to the concept and terminology of computer aided design, nor to the hardware utilized by a CAD system. But the interest, enthusiasm, and determination were present. The need was clear; information and advice must be made available to technology teachers concerning the implementation of computer aided design into their curriculum.

The following information is the compilation of many references, and is intended to provide both depth and breadth into the fascinating technology of computer-aided design, especially as it relates to the secondary technology curriculum.

#### CAD DEFINED

Before we can proceed, a common definition of computer-aided design must be laid down. Groover and Zimmers stated that "computer-aided design can be defined as the use of computer systems to assist in the creation, modification, analysis, or optimization of a design (Groover and Zimmers, 1984:1)." M. Zandi stated that computer-aided design is "the interactive use of digital computers to carry out the tasks of design and drafting (Zandi, 1985:3)." Gary Bertoline defines CAD as "the use of computers, software, and

associated hardware to produce drawings that would normally be prepared manually (Bertoline,1985:6)." All of these definitions point out key terms that would go into a common definition of CAD.

CAD systems use computer systems to to replace the tools of manual drafting used to assist the drafter. The key word is assist. The computer system does not draw the design for the drafter, although artificial intelligence is increasing that possibility. At this time, the CAD system is only a tool, as are a pencil, triangle, and eraser. The manual drafter uses a pencil to draw a line. A CAD operator uses an input device (keyboard, mouse, digitizer) to enter the endpoints of a line, and the computer completes the line. The manual drafter corrects his/her mistakes with an eraser. A CAD operator corrects mistakes by pointing to a line (circle, arc, etc.) to be erased, and it is erased. The manual operator draws on a sheet of paper. A CAD operator designs using the screen (cathode ray tube--CRT) until his/her drawing is complete, then plots the drawing using a plotter.

The benefits of a CAD system derive from the fact that a CAD system records a drawing with information in the computer, not with lead on a piece of paper. The difference is the medium of creating a design, and because a computer can manipulate large amounts of information in a short time, the CAD operator can also create, edit, and plot a drawing in a shorter amount of time than can a manual drafter.

#### THE BENEFITS OF CAD/CAM IN INDUSTRY

The computer's capability to manipulate large amounts of information involved in a drawing brings about many benefits over manual drafting. The first of these benefits is productivity.

The number of drawings produced in a given time is significantly higher

in firms using CAD systems. This is due to enhanced visualization of the object being designed, reduced time in synthesizing, analyzing, and documenting the design, and the simple fact that use of a CAD system is faster than manual manipulation. There are some dependencies that can affect the magnitude of productivity. The more complex, detailed, symmetrical and repetitive the drawing is, the more significant a CAD system can be. A CAD system can mirror one half of symmetrical drawing or make multiple copies of a part to be used many times in a particular drawing.

Where improvement in the quality of the design is concerned, a CAD system provides for a more thorough analysis of the design through application programs such as finite element analysis, mass properties analysis, ergonomics, simulation of machine tool paths, etc.

Improving communications and standardization, the use of a CAD system provides for standardization of documentation, lettering, greater legibility, and reduced drawing errors. Communication is enhanced through networking of the entire system for communication between management, designer, manufacturing engineer, and production supervisor.

A CAD system also provides for quicker customer modifications. Should a design need modifications, the drafter can bring the drawing out of memory, quickly change the required entity, and replot the design. This often can be done within an hour (Groover and Zimmers, 1984).

Finally, since a CAD system stores numerical information about the drawing in memory, the draftsman can analyze the properties of the part being designed. This often eliminates the need to make a manufacturing prototype since testing is simulated on the CAD system.

## CAD PURCHASING STRATEGY

### Introduction

The estimate that 1.2 million CAD operator positions will be available by 1990 prompts educational institutions to incorporate CAD into the industrial arts curriculum. Therefore, the question is not "whether to buy", but rather "what to buy." The purchase of a CAD system is not, by any means, a simple process. Vendors often confuse the client with conflicting claims of system capabilities. The following purchasing strategy is not all inclusive, but rather a sound beginning in the selection and purchase of a computer-aided design system.

### Selection Committee

The selection of a CAD system is a task that should not be performed alone. Consider an administrator, computer faculty, a representative from industry and/or a nearby university, and the technology faculty members who will be using the system.

Once organized, the beginning task of the selection committee is to gain a general knowledge about CAD.

### Researching the Concepts of CAD

It is advisable to know the fundamentals of computer-aided design to determine the CAD system's utilization as related to desired educational goals and objectives. The collection of information can be obtained from a variety of sources, including conferences, seminars, local colleges, professional magazines, trade shows, books, and vendor literature.

A list of textbooks, media, and professional journals concerning CAD are provided in Appendix A.

### Rationale for the Purchase

Although many administrators are supporting purchases of CAD systems, there may be questions. "Why do we need it?" "Can't you use existing computers?" "Won't industry supply you with something?", etc. Check available industrial, education, governmental and private resources for funding. Make sure your stance reflects industrial needs, and the objectives given for the CAD system are compatible with the mission of your department.

### Selecting a CAD System

Before talking to vendors, develop an evaluation chart to compare essential features among different CAD systems. One such chart was used in evaluating CAD systems in the March 11, 1986 edition of PC Magazine. An edited replication of this chart including features identified by Tony Weber of Gregg/McGraw Hill is found in Appendix B. Considerations are dependent upon the desired level of skill development your students need. Are the students being trained for industry standards or as a general orientation. As a rule, due to cost, educators use simulation equipment. It is also advisable to assess computers already owned by the school which could be used by the industrial education department for CAD work. A listing of microcomputer based CAD systems to look into is located in Appendix C.

Considerations when dealing with vendors include (Schwendau, 1984)

1. What courseware is available?
2. Are software updates included in the cost?
3. Is there a warranty and maintenance contract? What does it cover?
4. Where does the system go for repair?
5. Is there a training course for teachers? Cost?
6. Does the price include everything needed for operation?  
(cables, interfaces, operators manual)
7. Can backup copies of the software be made?
8. Does the vendor have any educational affiliations?
9. Is the vendor financially stable?
10. Does the sales representative have drafting background?
11. Are other customers happy with their service?
12. Does the local division vendor take care of all service?
13. Is there a local application specialist?
14. Is there an emergency hotline?
15. Who installs the system.

### Making the Final Purchase

Once the systems and vendors have been researched and a desired system chosen, it is appropriate to negotiate with different vendors. Computer prices are flexible, especially for larger purchases made by a school system or district. The key point is to not rush into a purchase. Take into account the information obtained from the previous steps and direct this knowledge toward selecting the best CAD system for the school's particular educational needs.

## CAD IN THE CLASSROOM

Teaching Methodolgy

There are three approaches to establishing CAD competencies in any drafting setting. The most common integration of CAD appears after students have developed proficiency in manual skills (use of pencil, triangle, etc.) and a drafting discipline. However, it is commonly agreed upon that CAD will become the primary drafting tool with manual skills developed only as backup. Therefore, educators are advised to take a different approach.

One approach is to establish competency in a drafting discipline using computers instead of drawing boards. In this setting, CAD skills are developed along with the drafting skills. Assignments are given in sequence of developing conceptual drafting skills (e.g. orthographic projection, section views, floor plans, electrical schematic); however, the assignment is completed only on a CAD system. No manual skills are used from the beginning of the course.

Another approach is to establish elementary competency in a drafting discipline using freehand sketching, then utilizing CAD and manual skills for industrial quality work. Much of the fundamental drafting concepts do not require the precision of drafting tools. Visual perception is best learned using freehand sketching as the student is not limited to the tools and can experieiment both in and out of the classroom. Usually home-work in a drafting couse is unheard of. This approach makes better use of class time as drill and practice is done outside the classroom.

The selected method rests on the strategy chosen by the teacher; however, as with most coursework, there are prerequisite skills which the student is advised to possess before using a CAD system.

### Prerequisite Skills

The respondents of Nielsen's 1985 study of CAD users indicated three skill areas to be developed either before or during experience with computer-aided design. These are 1) basic programming, 2) trigonometry, analytic geometry, and 3) a drafting discipline.

The student's capability to program in basic is not as important as the general operating skills learned during the introduction to microcomputers. When using a CAD system the student does not need to know a programming language, but must be able to operate the computer and peripheral equipment. It is also helpful for the student to have a fundamental understanding of how a microcomputer works so that they can identify the advantages of a CAD system resulting from the speed and capacity of the computer.

Trigonometry and analytic geometry form the basis for use of absolute, relative and polar coordinate systems relied on when using a CAD system. Since geometric construction on a CAD system utilizes the mind more than the hands, math skills are stressed. This recommendation does not refer to an in depth study of trigonometry, rather an orientation to basic trigonometry equations.

As stated before, a foundation in a drafting discipline is necessary for a student to apply the tools of drafting. The drafting skills and CAD skills may be developed concurrently. This eliminates "lettering for the sake of lettering" or "linework for the sake of linework" and makes drafting work relevant to the field of study.

### Competencies

In research done by Greg Peck of the Mexico, Missouri Vocational-Technical Center with the help of industrial CAD users and CAD educators, the consensus was that "priority be given to those features that make CAD

efficient and not hardware dependent features such as back-ups and plotting that vary greatly from one system to another (Peck, 1984:14). Although commands differ in syntax, features which are common among CAD systems include:

1. system operation (login/logout, file retrieve/save, plotting)
2. coordinate systems (absolute, relative, polar)
3. screen scales, magnification
4. entity creation (drawing lines, circles, arcs, fillets)
5. entity modification (erase, move, trim)
6. text (selecting style, inserting, modifying)
7. dimensioning (automatic, semi-automatic, vertical, horizontal, radial)
8. drawing aides (grids, object snap, orthogonal mode)
9. windowing (selecting a portion of the screen to work with)
10. layer selection (place parts on different levels of a drawing)
11. copy (make multiple copies of a part or group of parts)
12. mirror (make copies of symmetrical objects around an axis)
13. grouping (making multiple entities belong together)
14. symbol library (storing and recalling often used symbols and parts)

Depending on the program, these skills may be the only competencies required of the student; however, a vocational program will require a deeper understanding of CAD and especially its relationship to the manufacturing, construction, and electronics industries. Pedras and Hoggard (1985) developed a DACUM chart illustrating the specific duties and tasks performed by a Computer Drafting Technician. This chart, as illustrated in figure 1, is not drafting discipline specific but rather builds on a present knowledge of drafting principles.

**CLARK COUNTY COMMUNITY COLLEGE  
DACUM OCCUPATIONAL ANALYSIS  
COMPUTER DRAFTING TECHNICIAN**

**Definition: Computer Drafting Technician**

A trained drafter who must combine conventional drawing skill, theory and methods with the appropriate use of a CAD system. The specialist must be able to operate a basic CAD system, execute drawing assignments, change and execute detailed drawings, and prepare final drawings.

|                                              |                                   |                                        |                                                           |                                                    |                             |                           |                       |                       |                  |
|----------------------------------------------|-----------------------------------|----------------------------------------|-----------------------------------------------------------|----------------------------------------------------|-----------------------------|---------------------------|-----------------------|-----------------------|------------------|
| I<br>Utilize Computer                        | Log on/off system                 | Select appropriate program             | Utilize appropriate input/output device                   | Operate key-board proficiently                     | Maintain proper environment |                           |                       |                       |                  |
| II<br>Manage Library of Symbols              | Create and maintain symbol index  | Create and use symbols                 | Create and use symbol menus                               |                                                    |                             |                           |                       |                       |                  |
| III<br>Interpret Design Criteria             | Establish Job and task scope      | Interact with design team              | Plan approach                                             | Establish time frame                               |                             |                           |                       |                       |                  |
| IV<br>Prepare Preliminary Drawing            | Identify components               | Create data base file                  | Set screen/drawing parameters                             | Lay out the drawing                                | Utilize symbols             | Utilize text              | Select key dimensions | Produce check prints  | Obtain approvals |
| V<br>Prepare Finished Drawings               | Finalize drawing parameters       | Modify drawing to conform to standards | Select final dimensions                                   | Incorporate reference data and standard notations. | Select output parameters    | Produce final check print |                       | Produce final drawing |                  |
| VI<br>Maintain Support Files                 | Create and maintain drawing index | Create and maintain drawing files      | Implement security procedure for protection of file media | Implement appropriate back-up procedure            |                             |                           |                       |                       |                  |
| VII<br>Exploit System's Maximum Capabilities | Learn system capabilities         | Communicate system capabilities        | Apply knowledge to achieve maximum proficiency            |                                                    |                             |                           |                       |                       |                  |
| VIII<br>Troubleshoot System Problems         | Identify problem                  | Document problem                       | Resolve minor problems                                    | Refer to appropriate help sources                  |                             |                           |                       |                       |                  |
| IX<br>Must Remain Current in Field           | Participate in user groups        | Access vendor updates                  | Participate in professional associations                  | Continue education                                 | Use current publications    |                           |                       |                       |                  |

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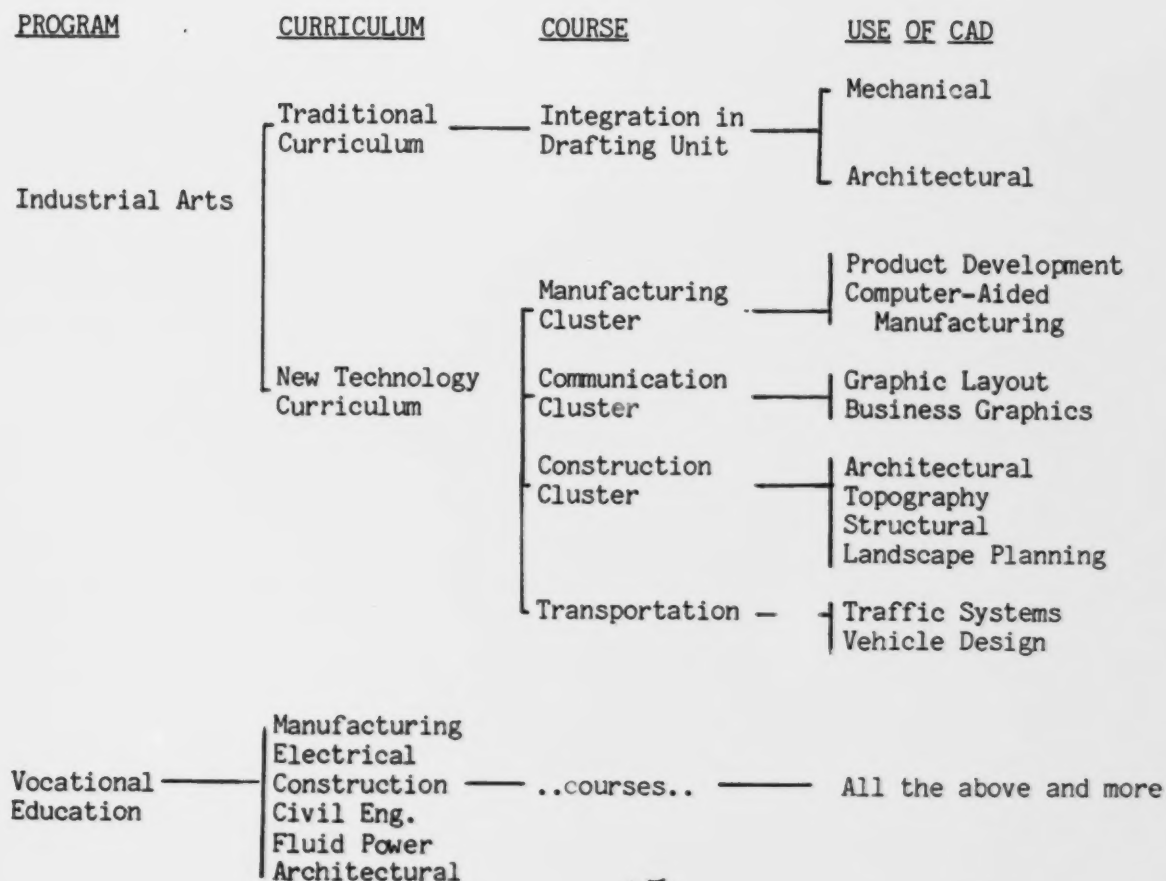
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Figure 1

### Program Area

There are many different areas in which a teacher could implement a CAD system. The area of emphasis is dependent on the particular objectives of the curriculum. Are the students being prepared for job entry skills? Is the program an introduction to technology? Figure 2 illustrates a sample breakdown of differing industrial education programs and the placement of a CAD system in those programs.

Figure 2  
Program Areas of CAD



The new emphasis on technology programs in the secondary curriculum offers a great opportunity to use a CAD system in a manufacturing or construction cluster. Recommendations made by industrial CAD users in Nielsen's 1985 study emphasized diverting away from a "paper" approach toward the "electronic age" and toward computer aided and computer integrated manufacturing . The Chrysler films noted in Appendix A provide a picture of CAD use in the industrial environment.

#### CONCLUSION

This paper has brought to light the many considerations encountered during the process of integrating computer-aided design into the industrial education curriculum. It is the responsibility of industrial educators to maintain abreast of current technology and incorporate emerging industrial techniques into the classroom.

Incorporating CAD becomes more a reality as the price of CAD software and computer hardware decrease. With careful consideration of equipment already owned by the school system and prudent budgeting techniques, even small school systems are given the the opportunity to display to students the latest technologies.

The methodology used in teaching drafting using traditional tools is not any different when using computer-aided design. A tool is a tool. The depth in which CAD is covered depends on the level of the student and the objectives of the program.

Our students deserve to be exposed to systems which affect the productivity of modern industry.

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Zandi, M. Computer Aided Design and Drafting. New York: Delmar Publishers, Inc., 1985.

\_\_\_\_\_. "Directory of Microcomputer CAD." T.H.E. Journal. June, 1986.

## Appendix A

## COURSE MATERIALS

Textbooks

CAD/CAM With Personal Computers  
Patrick R. Carberry  
Tab Books, Inc.  
Blue Ridge Summit, PA 17214

Mechanical CAD Lab Manual  
Donald Voisinet  
Gregg/McGraw Hill  
Princeton Road  
Hightstown, NY 08520

Computer Aided Design and Drafting  
M. Zandi  
Delmar Publishers Inc.  
2 Computer Drive West  
Box 15015  
Albany, NW 12212-5015

CAD Applications: Mechanical  
Gary Bertoline  
Delmar Publishers  
2 Computer Drive West  
Box 15015  
Albany, NW 12212-5015

Fundamentals of CAD  
Gary Bertoline  
Delmar Publishers  
2 Computer Drive West  
Box 15015  
Albany, NW 12212-5015

CAD Applications: Architectural  
David L. Goetsch  
Delmar Publishers  
2 Computer Drive West  
Box 15015  
Albany, NW 12212-5015

Introduction to CAD  
Donald Voisinet  
Gregg/McGraw Hill  
Princeton Road  
Hightstown, NY 08520

CAD Applications: Electronics  
Gerald R. Hansen, Elwood V. Hathaway  
Delmar Publishers  
2 Computer Drive West, Box 15015  
Albany, NW 12212-5015

The CAD/CAM Workbook  
David L. Goetsch  
The CAD/CAM Filmstrips  
South-Western Publishing Company  
355 Conde Street  
West Chicago, IL 60185

CAD/CAM Computer Aided Design & Drafting  
Mikell Groover, Emory Zimmers, Jr.  
Prentice-Hall, Inc.  
Englewood Cliffs, N.J. 07632

Architectural CAD Lab Manual  
Thomas Obermeyer  
Gregg/McGraw Hill  
Princeton Road  
Hightstown, NY 08520

Using AutoCAD  
James E. Fuller  
Delmar Publishers  
2 Computer Drive West  
Box 15015  
Albany, NW 12212-5015

Applying AutoCAD  
Terry T. Wohlers  
Glencoe Publishing  
17337 Ventura Boulevard  
Encino, California 91316

Introduction to Computer Aided Drafting  
David Goetsch  
Prentice-Hall, Inc.  
Englewood Cliffs, N.J. 07632

Media

Computer Aided Design, 1172, \$6  
 CAD/CAD Curriculum, #A-58, \$15  
 American Vocational Association  
 2020 North 14th Street  
 Arlington, VA 22201

CAD Computer Aided Design Explained  
 3 filmstrips/cassettes 860-V3, \$125  
 Bergwall Productions  
 106 Charles Lindbergh  
 Uniondale, NY 11553

CAD Ventures Unlimited  
 CAD/CAM, filmstrip/cassette,  
 M 6354, \$35  
 Career Aids Inc.  
 8950 Lurline Avenue  
 Chatsworth, CA 91311

CAD/CAM Basics  
 80 color slides, \$103  
 DMR Associates  
 P.O. Box 255A  
 West Gordon, MA 01472

Microcomputer CAD  
 VSH videotape, \$60  
 Hollywood Video  
 5 East Lee Street  
 Plano, IL 60545

Commitment to the Future  
 16 mm movie  
 The Innovators, 16mm movie  
 158 Carmen Drive  
 Elk Grove Village, IL 60007

"The Challenge of Manufacturing"  
 16 mm Movie, \$185  
 Modern Talking Picture Service, Inc.  
 5000 Park St. North  
 St. Petersburg, FL 33709

"Just in Time"  
 16 mm Movie, free loan  
 Modern Talking Picture Service, Inc.  
 5000 Park St. North  
 St. Petersburg, FL 33709

"For Years to Come"  
 16 mm Movie, free loan  
 Modern Talking Picture Service, Inc.  
 5000 Park St. North  
 St. Petersburg, FL 33709

CAD/CAM Technology  
 Filmstrips, \$210; slides \$79; video \$89  
 Meridian Education Corporation  
 205 E. Locust St.  
 Bloomington, IL 61701

Computer Aided Drafting  
 Video, \$219; free preview  
 Vocational Media Associates, Prentice-Hall  
 P.O. Box 1050  
 Mount Kisco, NY 10549

The CAD/CAM Filmstrips  
 4 Filmstrips, 2 Cassettes, \$195  
 South-Western Publishing Co.  
 5101 Madison Road  
 Cincinnati, OH 45227

Directories, Periodicals

A Survey Low Cost Systems  
Leading Edge Publications  
317 Forest Central Two  
11551 Forest Central Drive  
Dallas, TX 75243

The Anderson Report  
P.O. Box 3616  
Simi Valley, CA 93063

CAD/CAM Alert  
822 Boylston Street  
Chestnut Hill, MA 02167

The CAD/CAM Digest  
Productivity International  
5622 Dyer Street, Suite 220  
Dallas, TX 75206

The CAD/CAM Handbook  
Computervision Corporation  
201 Burlington Avenue  
Bedford, MA 01730

The CAD/CAM Industry Directory  
Contract Technical Database Corp.  
PO Box 720  
Conroe, TX 77305

Computer-Aided Design Report  
841 Turquoise Street  
Suite D & E  
San Diego, CA 92109

Computer Design  
119 Russel Street  
Littleton, MA 01460

Computer Graphics News  
2033 M Street, N.W., Suite 330  
Washington, D.C. 20036

Computer Graphics World  
PO Box 122  
Tulsa, OK 74101

Automation News  
CAD/CIM/CAM Technology  
Computer Aided Engineering  
Computer Graphics News  
Computer Graphics World  
Industrial Education

Design News  
270 St. Paul Street  
Denver, CO 80206

Digital Design  
1050 Commonwealth Avenue  
Boston, MA 02215

Engineering Design Graphics Journal  
2070 Neil Avenue  
Columbus, OH 43201

Engineering News Record  
PO Box 516  
Highstown, NJ 08520

High Technology  
PO Box 5239  
Boulder, CO 80322

Machine Design  
Penton Plaza  
Cleveland, OH 44114  
Plan and Print  
10116 Franklin Avenue  
Franklin Park, IL 60131

The S. Klein Newsletter on Computer  
Graphics  
730 Boston Post Road, PO Box 89  
Sudbury, MA 01776

Computer Graphics: U.S. Directory of  
Vendors  
Daratech, Inc.  
16 Myrtle Ave.  
P.O. Box 410  
Cambridge, MA 02138

Design Drafting and Reprographics  
390 Fifth Avenue  
New York, NY 10018

Designfax  
6521 Davis Industrial Parkway  
Solon, OH 44139

Appendix B  
EVALUATION OF CAD SYSTEM

Evaluator \_\_\_\_\_

System a: \_\_\_\_\_ Vendor: \_\_\_\_\_

System b: \_\_\_\_\_ Vendor: \_\_\_\_\_

System c: \_\_\_\_\_ Vendor: \_\_\_\_\_

|                             | System |   |   |
|-----------------------------|--------|---|---|
|                             | a      | b | c |
| Entity Draw Commands        |        |   |   |
| Line                        |        |   |   |
| Auto line closing           |        |   |   |
| Continuation                |        |   |   |
| Wide lines                  |        |   |   |
| Parallel lines              |        |   |   |
| Line types                  |        |   |   |
| Number of line weights      |        |   |   |
| Mix line types on one layer |        |   |   |
| Mix color on one layer      |        |   |   |
| Point/node                  |        |   |   |
| Circle                      |        |   |   |
| Center/radius               |        |   |   |
| Center/diameter             |        |   |   |
| 3 point                     |        |   |   |
| 2 point                     |        |   |   |
| Arc                         |        |   |   |
| 3 point                     |        |   |   |
| Center, radius radians      |        |   |   |
| other _____                 |        |   |   |
| Ellipse                     |        |   |   |
| Multipoint curve            |        |   |   |
| Rectangle                   |        |   |   |
| Rounded rectangle           |        |   |   |
| Square                      |        |   |   |
| Polygons                    |        |   |   |
| Polylines                   |        |   |   |
| Solid areas                 |        |   |   |
| Arrows                      |        |   |   |
| Text                        |        |   |   |
| Centering                   |        |   |   |
| Auto-aligned                |        |   |   |
| Font changes                |        |   |   |
| Rotation                    |        |   |   |
| Boldface                    |        |   |   |

## Drawing assistance

|                    |  |  |  |
|--------------------|--|--|--|
| Snap               |  |  |  |
| Variable sizing    |  |  |  |
| Rotation           |  |  |  |
| Isometric          |  |  |  |
| Angle              |  |  |  |
| Align              |  |  |  |
| Aspect             |  |  |  |
| Grid               |  |  |  |
| Variable sizing    |  |  |  |
| Aspect             |  |  |  |
| Axis               |  |  |  |
| Variable sizing    |  |  |  |
| Aspect             |  |  |  |
| Orthogonal mode    |  |  |  |
| Object snap        |  |  |  |
| Nearest            |  |  |  |
| Endpoint           |  |  |  |
| Midpoint           |  |  |  |
| Center of circle   |  |  |  |
| Node/point         |  |  |  |
| Quadrant of circle |  |  |  |
| Intersection       |  |  |  |
| Perpendicular      |  |  |  |
| Tangent            |  |  |  |
| Polar              |  |  |  |

## Editing Commands

|                    |  |  |  |
|--------------------|--|--|--|
| Selection          |  |  |  |
| Groups of objects  |  |  |  |
| Individual objects |  |  |  |
| Windows            |  |  |  |
| Multiple Windows   |  |  |  |
| Last object        |  |  |  |
| By entity type     |  |  |  |
| Erase              |  |  |  |
| Unerase            |  |  |  |
| Move               |  |  |  |
| Copy               |  |  |  |
| Mirror image       |  |  |  |
| Rotation           |  |  |  |
| Endpoint join      |  |  |  |
| Resizing           |  |  |  |
| Layer change       |  |  |  |
| Area fill          |  |  |  |
| Break/trim         |  |  |  |
| Lines              |  |  |  |
| Circles/arcs       |  |  |  |
| Fillet             |  |  |  |
| Chamfer            |  |  |  |
| Arrays             |  |  |  |
| Rectangular        |  |  |  |
| Circular           |  |  |  |
| Segment line/arc   |  |  |  |



## Blocks

Define from active file  
 Saved on disk  
 Size scaling on insertion  
 Rotation on insertion

|       |       |       |
|-------|-------|-------|
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| _____ | _____ | _____ |
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| _____ | _____ | _____ |

## Hatching

Number of patterns  
 User defined patterns  
 Hatching styles

|       |       |       |
|-------|-------|-------|
| _____ | _____ | _____ |
| _____ | _____ | _____ |
| _____ | _____ | _____ |

## Attributes

Visible/invisible  
 Editable  
 other \_\_\_\_\_  
 other \_\_\_\_\_

|       |       |       |
|-------|-------|-------|
| _____ | _____ | _____ |
| _____ | _____ | _____ |
| _____ | _____ | _____ |
| _____ | _____ | _____ |

## Help

On screen  
 Context sensitive  
 Disk tutorial

|       |       |       |
|-------|-------|-------|
| _____ | _____ | _____ |
| _____ | _____ | _____ |
| _____ | _____ | _____ |
| _____ | _____ | _____ |

## Plotting controls

Variable sizing  
 Pen speed control  
 Pen force control  
 Pen acceleration control  
 Plot rotation  
 Automatic scaling  
 Exact scaling  
 Spooling  
 Plotter optimization

|       |       |       |
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## Miscellaneous commands

Command scripts  
 Slide shows  
 Programming language  
 User defined screen menus  
 Tablet menus  
 Freehand sketching  
 3 dimensional  
 DOS type commands  
 Execute DOS within CAD  
 Symbol library  
 Metrification of dimensions  
 Size restrictions on plotter  
 Bill of material generation  
 Networking capabilities

|       |       |       |
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## APPENDIX C

## MICROCOMPUTER CAD SOFTWARE VENDORS

A June 1986 survey of microcomputer CAD systems for education conducted by the staff of the Technical Horizons in Education Journal uncovered thirty such systems. The survey requested important information as operating system used, design capabilities, peripheral devices, and price. The list, as it appears in the June 1986 edition of T.H.E. Journal, appears on the following four pages.

Systems not covered by the T.H.E. Journal appear below.

| COMPANY/SOFTWARE                                                                                 | EQUIPMENT/COST                                                                          |
|--------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------|
| BG Graphics System, Inc.<br>Drawing Processor<br>824 Stetson Avenue<br>Kent, WA 98031            | IBM PC and compatibles<br>Cost: \$1,000                                                 |
| Datagraphics<br>CAD Master<br>7011 Biscayne<br>Milford, MI 48042                                 | IBM PC<br>Cost: \$1,100-\$1,800<br>Excellent drafting capability                        |
| Metasoft Corporation<br>Benchmark<br>6509 West Frye Road<br>Chandler, AZ 85224                   | IBM PC and compatibles<br>Cost: \$600<br>Introductory Package                           |
| Micrographix<br>PC-Draw<br>1701 North Greenville<br>Richardson, TX 75081                         | IBM PC and compatibles<br>Cost: \$250<br>Very basic package                             |
| Personal CAD Systems<br>CADplan and CADdraft<br>15425 Los Gatos Boulevard<br>Los Gatos, CA 95030 | IBM PC and compatibles<br>Cost: \$500-\$1,300<br>Entry level or introductory<br>Package |

# Directory of Microcomputer CAD Systems for Education

The following companies responded to a survey conducted by T.H.E. JOURNAL. Each manufacturer was asked to provide information on two CAD systems. This directory is not intended to be comprehensive, and a product listing does not imply an endorsement. (See Technology Update, page 12.)

| Software/<br>Manufacturer                                                                                                                   | Operating<br>System(s)   | Design<br>Capabilities                                                                                                                            | Special<br>Capabilities                                                                                                                                               | No. of Layers | No. of Colors | Recommended<br>RAM | Disk Drive<br>Configuration               | Graphics<br>Hardware                                     | Input Devices<br>Supported                                         | Price                                                                                       |
|---------------------------------------------------------------------------------------------------------------------------------------------|--------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------|---------------|--------------------|-------------------------------------------|----------------------------------------------------------|--------------------------------------------------------------------|---------------------------------------------------------------------------------------------|
| <b>Schematic Entry</b><br>Advanced Engineering<br>Solutions, Inc.<br>75 Manhattan Drive<br>Suite 302<br>Boulder, CO 80303<br>(303) 499-2910 | Macintosh                | Grid, snap, text,<br>zoom, windowing,<br>design database                                                                                          | Netlist translators<br>to Scicards, Gerber,<br>Calay, Computer-<br>vision; written in<br>Modula-2                                                                     |               |               | 512K               | External<br>floppy disk<br>drive required |                                                          | Digitizer,<br>mouse,<br>keyboard                                   | \$700*                                                                                      |
| <b>AutoCAD</b><br>Autodesk, Inc.<br>2320 Marinship Way<br>Sausalito, CA 94965<br>(415) 332-2344                                             | MS-DOS,<br>UNIX          | 2D, 3D, AI capabil-<br>ity, grid, snap fitted<br>curves, text, zoom,<br>pan, rotation,<br>windowing, freehand<br>sketching, polylines,<br>splines | Hidden-line removal;<br>user-definable<br>macros; interfaces<br>available for CNC<br>machines; supports<br>C and LISP                                                 | Unltd.        | Un-<br>ltd.   | 512K               | Hard disk<br>recommended                  | Graphics card                                            | Digitizer,<br>mouse,<br>keyboard,<br>joystick                      | Contact<br>your local<br>AutoCAD<br>dealer*                                                 |
| <b>Cadkey, 3D V2.0</b><br>Brodhead-Garrett Co.<br>4560 E. 7th St.<br>Cleveland, OH 44105<br>(216) 341-0248                                  | DOS 2.0<br>or higher     | 2D, 3D, grid,<br>snap, text, zoom,<br>windowing                                                                                                   | Mesh generation;<br>projected tangencies<br>in true 3D; off-line<br>plotting; written in<br>C; IGES translator<br>available for main-<br>frame or CAM con-<br>nection | 256           | 16            | 640K               | One floppy,<br>one hard disk              | High-resolu-<br>tion mono-<br>chrome or<br>color monitor | Digitizer,<br>mouse,<br>keyboard                                   | \$2,695;<br>\$495 for<br>eight or<br>more                                                   |
| <b>CADillac-M</b><br>CAD Technologies<br>5225 Old Orchard Road<br>Suite 4<br>Skokie, IL 60077<br>(312) 967-8900                             | MS-DOS                   | Same as AutoCAD<br>plus mechanical<br>designers                                                                                                   | Ancillary to<br>AutoCAD                                                                                                                                               |               |               |                    |                                           |                                                          | Digitizer                                                          | \$590*                                                                                      |
| <b>CADVANCE</b><br>CalComp<br>Personal Systems Unit<br>200 Hacienda Ave.<br>Campbell, CA 95008<br>(408) 866-6272                            | MS-DOS                   | 2D, 3D, grid,<br>snap, fitted curves,<br>text, zoom, pan,<br>rotation, windowing,<br>DXF, IGES                                                    | Cleans up parallel<br>line (architectural<br>wall) intersections;<br>moves vertices to<br>stretch walls, sup-<br>ports four foreign<br>languages                      | 127           | 16            | 512K               | 10M hard disk                             | 320x200<br>(minimum)<br>graphics card                    | Digitizer,<br>mouse,<br>keyboard                                   | \$2,500*                                                                                    |
| <b>CADlab</b><br>Cascade Graphics Systems<br>16842 Von Karman Ave.<br>Irvine, CA 92714<br>(714) 474-6200                                    | Apple IIe,<br>IBM PC, XT | 2D, grid,<br>snap, text, zoom,<br>windowing, mirror-<br>ing, step-repeat                                                                          | Eight discipline-<br>specific libraries;<br>two-digit drawing<br>functions; supports<br>C-BASIC and<br>UNIX                                                           | 256           | 8             | 256K               | One or two<br>double-sided<br>disk drives | 624x1,024<br>monochrome or<br>color monitor              | Digitizers,<br>light pens,<br>keyboards,<br>joysticks,<br>scanners | \$1,000-<br>\$1,500*                                                                        |
| <b>microCADDs</b><br>Computervision Corp.<br>Personal Systems<br>Business Unit<br>2 Crosby Drive<br>Bedford, MA 01730<br>(617) 275-1800     | PC-DOS 2.1<br>or higher  | 2D, 3D, grid,<br>snap, fitted curves,<br>text, zoom, pan,<br>rotation, windowing,<br>stretch, trim, divide                                        | 3D wireframe and<br>surface modeling;<br>drawing production<br>to engineering<br>standards; written<br>in UPL                                                         | 255           | 16            | 512K               | 10M hard disk,<br>20M preferred           | Advanced<br>graphics<br>card                             | Key-<br>board,<br>tablet or<br>on-screen<br>menus                  | \$5,800 for<br>Geometric<br>Construc-<br>tion and<br>Detailing,<br>\$2,800 for<br>Surfaces* |

\*Educational discounts available

| Software/<br>Manufacturer                                                                                                                       | Operating<br>System(s)                | Design<br>Capabilities                                                                                                                                           | Special<br>Capabilities                                                                                                                             | No. of Layers | No. of Colors | Recommended<br>RAM        | Disk Drive<br>Configuration                                                                | Graphics<br>Hardware                                    | Input Devices<br>Supported                                            | Price                                            |
|-------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------|---------------|---------------|---------------------------|--------------------------------------------------------------------------------------------|---------------------------------------------------------|-----------------------------------------------------------------------|--------------------------------------------------|
| <b>Models 912 and 920</b><br>Integrated Imaging Systems<br>Datacopy Corp.<br>1215 Terra Bella Ave.<br>Mountain View, CA 94043<br>(415) 965-7900 | PC-DOS and WIPS<br>EDITOR<br>software | Turnkey systems that<br>allows the user to scan<br>existing draw-<br>ings and feed them in-<br>to AutoCAD; includes<br>3D, text, zoom,<br>rotation,<br>windowing | WIPS EDITOR (Word<br>Imaging Processing<br>Software) has edit-<br>ing and drawing<br>capabilities                                                   |               |               | 640K                      |                                                                                            |                                                         | Digitizer,<br>power<br>supply,<br>lights all<br>included<br>in system |                                                  |
| <b>EmcoCam</b><br>Emco Maier Corp.<br>2050 Fairwood Ave.<br>Columbus, OH 43207<br>(614) 445-8328                                                | MS-DOS 2.0<br>or higher               | CAD/CAM: 2D,<br>text, zoom, pan,<br>rotation, windowing                                                                                                          | Ancillary to Auto-<br>CAD                                                                                                                           | 8             | 8             | 512K                      | Two 230K disk<br>drives mini-<br>mum, or one<br>360K disk<br>drive and one<br>5M hard disk | Color graphics<br>card and<br>monitor                   | Digitizer                                                             | \$2,250                                          |
| <b>Generic CADD</b><br>Generic Software, Inc.<br>8763 148th St. NE<br>Redmond, WA 98052<br>(206) 885-5307<br>(800) 228-3601                     | PC-DOS 2.0<br>or higher               | 2D, grid, snap, text,<br>zoom, rotation, win-<br>dowing, mirroring,<br>stretching, shrinking                                                                     | User-defined<br>video and digitizer<br>menus; Auto-Convert<br>package transfers<br>files to and from<br>AutoCAD                                     | 256           | 256           | 512K-<br>640K             | Two 360K<br>floppy disk<br>drives or one<br>floppy disk<br>drive and one<br>hard disk      | Graphics card<br>and matching<br>monitor                | Digitizer,<br>mouse                                                   | \$99                                             |
| <b>PC-GRASP</b><br>GRASP, Inc.<br>RD3 Box 233A<br>Troy, NY 12180<br>(518) 279-9414                                                              | DOS 3.1 and<br>VDI device<br>drivers  | CAD/CAM: 3D,<br>text, zoom, rotation,<br>windowing                                                                                                               | Allows the model-<br>ing and multi-image<br>display of a one to<br>six jointed robot;<br>simulation                                                 |               | 8             | 512K                      | Hard disk                                                                                  | Professional<br>graphics<br>controller                  | Mouse<br>optional                                                     | \$2,500                                          |
| <b>discoverCAD</b><br>Hearlity & Co.<br>714 W. Columbia St.<br>P.O. Box 869<br>Springfield, OH 45501<br>(800) 622-1000<br>(513) 324-5721        | Apple IIe<br>or IIc,<br>DOS 3.3       | 2D, grid, snap, text,<br>zoom, pan, rotation,<br>windowing, freehand<br>sketching, automatic<br>dimensioning mirror-<br>ing                                      | Support for NC<br>host processors,<br>adjustable grid and<br>snap; written in<br>PASCAL                                                             | 128           |               | 128K                      | Two floppy<br>disk drives                                                                  | Monochrome<br>monitor and<br>Apple Super<br>Serial Card | Mouse,<br>keyboard                                                    | \$209 for<br>schools                             |
| <b>CADDRAW</b><br>Hearlity & Co.<br>714 W. Columbia St.<br>P.O. Box 869<br>Springfield, OH 45501<br>(800) 622-1000<br>(513) 324-5721            | Apple II+,<br>IIe or IIc,<br>DOS 3.3  | 2D, 3D, grid, snap,<br>text, rotation,<br>windowing, freehand<br>sketching, automatic<br>centering                                                               | Support for NC<br>host processors;<br>point-by-point<br>plotting of solid<br>and hidden lines at<br>any thickness;<br>written in Applesoft<br>BASIC | 2             | 8             | 64K,<br>48K on<br>the II+ | One floppy<br>disk drive                                                                   | Monochrome<br>or color<br>monitor                       | Keyboard                                                              | \$123 for<br>schools                             |
| <b>CAD/BASIC</b><br>Kern International, Inc.<br>575 Washington St.<br>Pembroke, MA 02359<br>(617) 826-0095                                      | MS-DOS or<br>PC DOS 1.1<br>or higher  | 2D, grid, fitted<br>curves, text, zoom,<br>pan, rotation                                                                                                         | Semi-automatic<br>dimensioning, written<br>in BASIC                                                                                                 |               |               | 64K                       | One floppy<br>disk drive                                                                   | Graphics card                                           | Keyboard                                                              | \$120*                                           |
| <b>DESIGNER 3D</b><br>Kern International, Inc.<br>575 Washington St.<br>Pembroke, MA 02359<br>(617) 826-0095                                    | MS-DOS or<br>PC-DOS 1.1               | 3D, fitted curves,<br>text, zoom, pan,<br>rotation                                                                                                               | 3D curve fitting;<br>source code included;<br>written in BASIC                                                                                      | 10            |               | 64K                       | One floppy<br>disk drive                                                                   | Graphics card                                           | Keyboard                                                              | \$120                                            |
| <b>Designfile</b><br>Lovelace-Lawrence & Co.<br>18 Broad St.<br>Charleston, SC 29401<br>(803) 577-7838                                          | MS-DOS,<br>Modua 2                    | AI capability,<br>graphics file<br>manager                                                                                                                       | Classification and<br>coding for parts and<br>assemblies for CAD<br>design libraries.                                                               |               |               | 128K                      |                                                                                            |                                                         | Keyboard,<br>mouse                                                    | \$5,000-<br>\$15,000,<br>available<br>in modules |

\*Educational discounts available

| Software/<br>Manufacturer                                                                                            | Operating<br>System(s)                              | Design<br>Capabilities                                                                                                        | Special<br>Capabilities                                                                                                                                          | No. of Layers | No. of Colors<br>Recommended<br>RAM   | Disk Drive<br>Configuration                                                   | Graphics<br>Hardware                                      | Input Devices<br>Supported                    | Price                |
|----------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------|---------------------------------------|-------------------------------------------------------------------------------|-----------------------------------------------------------|-----------------------------------------------|----------------------|
| <b>MATC-CAD</b><br>MATC-CAD<br>1015 N. Sixth St.<br>Milwaukee, WI 53203<br>(414) 278-6743                            | Apple or<br>IBM PC                                  | 2D; grid, snap,<br>text, zoom, rotation,<br>windowing                                                                         | Instructor and<br>student materials set<br>up in a suggested<br>curriculum, including<br>tests, exercises and<br>answers; written in<br>PASCAL                   | 256           | 64K<br>(Ap-<br>ple),<br>256K<br>(IBM) | Two disk<br>drives                                                            | Apple graphics<br>tablet (Apple),<br>Kura tablet<br>(IBM) | Keyboard,<br>joystick                         | \$500                |
| <b>Design Board Professional</b><br>Mega CADD, Inc.<br>401 Second Ave., South<br>Seattle, WA 98104<br>(206) 623-6245 | MS-DOS                                              | 3D; grid, snap,<br>zoom, pan, rotation,<br>windowing, curved<br>surfaces                                                      | Unlimited perspec-<br>tives; isometric and<br>orthographic views;<br>automatic hidden line<br>removal; link to 2D<br>drafting software;<br>written in<br>FORTRAN | 2             | 512K                                  | Two floppy<br>disk drives<br>or hard disk                                     | Graphics card                                             | Digitizer,<br>mouse                           | \$1,750*             |
| <b>Design Board Illustrator</b><br>Mega CADD, Inc.<br>401 Second Ave., South<br>Seattle, WA 98104<br>(206) 623-6245  | MS-DOS                                              | Grid, snap, fitted<br>curves, text, zoom,<br>pan, rotation, win-<br>dowing, freehand<br>sketching                             | Paint, animation and<br>slide shows; CADD<br>enhancement and<br>presentation; written<br>in FORTRAN                                                              | 256           | 256K                                  | Two floppy<br>disk drives<br>or hard disk                                     | Graphics card                                             | Digitizer,<br>mouse                           | \$395*               |
| <b>MEGASYSTEMS 32000</b><br>Megsystems<br>2741 W. Southern<br>Suite 24B<br>Tempe, AZ 85282<br>(602) 438-0954         | MS-DOS 3.1<br>or higher                             | Workstation and<br>file server that<br>runs AutoCAD in a<br>network configu-<br>ration                                        | MEGANET net-<br>working software<br>runs Lotus 1-2-3,<br>dBASE, WordStar                                                                                         |               | 512K-<br>640K                         | 10M hard disk<br>on file server                                               | Supports<br>Autodesk<br>peripherals                       | On-screen<br>touch digi-<br>tizer             | \$3,800*             |
| <b>MICAD-SE, MICAD-CRM</b><br>MiCAD Systems, Inc.<br>419 Park Ave. South<br>New York, NY 10016<br>(212) 213-9350     | MS-DOS                                              | 2D, 3D, AI capabil-<br>ity, grid, snap, fitted<br>curves, text, zoom,<br>pan, rotation, win-<br>dowing, freehand<br>sketching | Ancillary to<br>AutoCAD                                                                                                                                          | Unltd         | 16<br>640K                            | Hard disk                                                                     | Graphics card<br>and monitor                              | Digitizer                                     | \$5,000<br>and up    |
| <b>CADKEY</b><br>Micro Control Systems,<br>27 Hartford Turnpike<br>Vernon, CT 06066<br>(203) 647-0220                | MS-DOS<br>Inc.                                      | CAD/CAM: 2D, 3D;<br>grid, snap, fitted<br>curves, text, zoom,<br>pan, rotation, win-<br>dowing, freehand<br>sketching         | Unlimited number of<br>views; 3D splines, x,<br>y and z axes, all<br>views simultaneously<br>updated; written in C                                               | 256           | 16<br>512K                            |                                                                               | Graphics card,<br>monitor                                 | Mouse,<br>keyboard,<br>2D<br>tablet           | \$495 for<br>schools |
| <b>In*Vision</b><br>Micrografx, Inc.<br>1820 No. Greenville Ave.<br>Richardson, TX 75081<br>(214) 234-1769           | MS-DOS 2.0<br>or higher, or<br>Microsoft<br>windows | 2D; grid, snap, text,<br>zoom, pan, rotation,<br>windowing, freehand<br>sketching, mirroring                                  | Undo feature; dif-<br>ferent line widths and<br>styles; cross-<br>hairs; user-definable<br>rulers; written in C                                                  | 16            | 8<br>320K                             | Hard disk                                                                     | Graphics<br>adapter<br>(IBM EGA<br>required<br>for color) | Mouse,<br>keyboard,<br>light pen,<br>joystick | \$495*               |
| <b>CAD-2</b><br>Robo Systems<br>111 Pheasant Run<br>Newtown, PA 18940<br>(215) 968-4422                              | AppleDOS                                            | 2D; grid, snap, text,<br>zoom, rotation, free-<br>hand sketching                                                              |                                                                                                                                                                  | Unltd         | 128K                                  | Two floppy<br>disk drives                                                     | Complete<br>Apple IIe<br>system                           | Joystick<br>controller                        | \$1,320              |
| <b>ROBOCAD-PC</b><br>Robo Systems<br>111 Pheasant Run<br>Newtown, PA 18940<br>(215) 968-4422                         | MS-DOS<br>or PC-DOS                                 | 2D; grid, snap, fitted<br>curves, text, zoom,<br>pan, rotation, free-<br>hand sketching                                       | Partial erase, partial<br>change, fillet, tangent,<br>radial snap grid,<br>orth lock, angle lock                                                                 |               | 640K                                  | Two floppy<br>disk drives<br>or one floppy<br>disk drive and<br>one hard disk | Graphics card,<br>monochrome<br>monitor                   | Digitizer,<br>mouse                           | \$1,495              |

\*Educational discounts available

| Software/<br>Manufacturer                                                                                               | Operating<br>System(s)             | Design<br>Capabilities                                                                                  | Special<br>Capabilities                                                                                                                                            | No. of Layers | No. of Colors | Recommended<br>RAM             | Disk Drive<br>Configuration                      | Graphics<br>Hardware                                        | Input Devices<br>Supported        | Price                                  |
|-------------------------------------------------------------------------------------------------------------------------|------------------------------------|---------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------|---------------|--------------------------------|--------------------------------------------------|-------------------------------------------------------------|-----------------------------------|----------------------------------------|
| VersaCAD Advanced<br>T & W Systems<br>7372 Prince Drive<br>Huntington Beach, CA 92647<br>(714) 847-9960                 | MS-DOS,<br>UNIX                    | 2D: grid, snap, fitted<br>curves, text, zoom,<br>pan, rotation, win-<br>dowing, freehand<br>sketching   | Multi-line draw<br>(up to 250); 3D<br>isometric views;<br>automatic break;<br>cut and paste;<br>fillet, curve and<br>dimension                                     | 250           | 256           | 640K                           | Two floppy<br>disk drives<br>or one hard<br>disk | Graphics card                                               | Digitizer,<br>mouse,<br>key board | \$2,495                                |
| CADAPPLE 3.0/3.5<br>T & W Systems<br>7372 Prince Drive<br>Huntington Beach, CA 92647<br>(714) 847-9960                  | MS-DOS,<br>UNIX                    | 2D, 3D: grid, snap,<br>text, zoom, rotation,<br>windowing                                               | Symbol libraries                                                                                                                                                   | 250           | 16            | 64K<br>(3.0),<br>128K<br>(3.5) | Two floppy<br>disk drives                        | Built in                                                    | Digitizer,<br>mouse,<br>joystick  | \$1,495*                               |
| SuperCads<br>Tavir Corp.<br>1091 Stierlin Road<br>Mountain View, CA 94043<br>(415) 964-7000                             | XENIX V                            | 2D, 3D: grid, snap,<br>fitted curves, text,<br>zoom, pan, rotation,<br>windowing                        | Model mode; draw-<br>ing mode; figure<br>capabilities; full<br>graphic editing;<br>written in C                                                                    | 256           | 4,096         | 2.9M                           | 1.2M hard<br>disk                                | Graphics card                                               | Digitizer,<br>keyboard            | \$18,900<br>PC/AT<br>turnkey<br>system |
| Auto Word Plus<br>Technical Software, Inc.<br>28790 Chagrin Blvd.<br>Cleveland, OH 44122<br>(216) 765-133               | MS-DOS                             | Text, automatic<br>scheduling genera-<br>tion                                                           | Ancillary to Auto-<br>CAD; works with<br>any ASCII file;<br>translates text<br>files from word<br>processor into<br>AutoCAD drawing                                |               |               | 64K                            | One floppy<br>disk drive or<br>one hard disk     | None<br>required                                            | None<br>required                  | \$150*                                 |
| 3-D GRAPHIXX<br>Universal Intergraphix<br>Corp.<br>2990 E. G Street<br>Suite 108<br>Ontario, CA 91764<br>(714) 989-3992 | MS-DOS or<br>PC-DOS<br>2.x and 3.x | 2D, 3D: grid, snap,<br>fitted curves, text,<br>zoom, pan, rotation,<br>windowing, freehand<br>sketching | Real-time animation;<br>slide shows; libraries;<br>line and planes inter-<br>sect planes; auto<br>dimensioning; z-axis<br>can be drawn any-<br>where; written in C | 256           | 16            | 640K                           | 10M hard disk                                    | IBM CGA<br>graphics<br>adapter and<br>compatible<br>monitor | Digitizer,<br>mouse               | \$3,995*                               |

\*Educational discounts available